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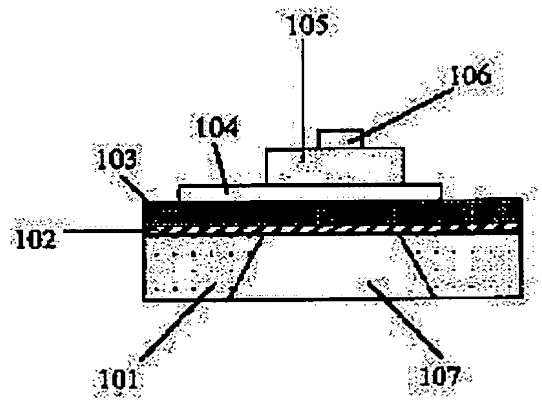
(71)Applicant : MITSUBISHI ELECTRIC CORP
(72)Inventor : MAEDA CHISAKO
YAMADA AKIRA
UCHIKAWA HIDEFUSA
MISU KOICHIRO
WADAKA SHUZO

(54) PIEZOELECTRIC THIN FILM ELEMENT

(57)Abstract:
PROBLEM TO BE SOLVED: To enhance the reliability of a piezoelectric element by composing piezoelectric element of a first electrode conductor thin film for driving it, a piezoelectric thin film formed thereon, and at least one second electrode thereby enhancing the performance of the piezoelectric thin film.
SOLUTION: A lower underlying film 102 of SiNx is formed on an Si single crystal substrate 101 and an upper underlying film 103 of SiO2 is formed thereon. A Pt/Ti film is then formed as a lower electrode (first electrode) 104 on the upper underlying film 103 and a piezoelectric thin film 105 is formed by depositing PtTiO3 on the lower electrode 104. Subsequently, an upper electrode (second electrode) 106 of formed of Pt/Ti film on the piezoelectric thin film 105. Finally, the surface of the substrate 101 is covered with glass and wax and the part corresponding to the upper electrode 106 is removed completely from the rear surface by wet etching. A compact piezoelectric thin film 105 can be formed through existence of the upper underlying film 103.



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(71)出願人　000006013
三菱電機株式会社
東京都千代田区丸の内二丁目2番3号

(72)発明者　前田　智佐子
東京都千代田区丸の内二丁目2番3号　三菱電機株式会社内

(72)発明者　山田　朗
東京都千代田区丸の内二丁目2番3号　三菱電機株式会社内

(74)代理人　100062144
弁理士　青山　葆　(外2名)

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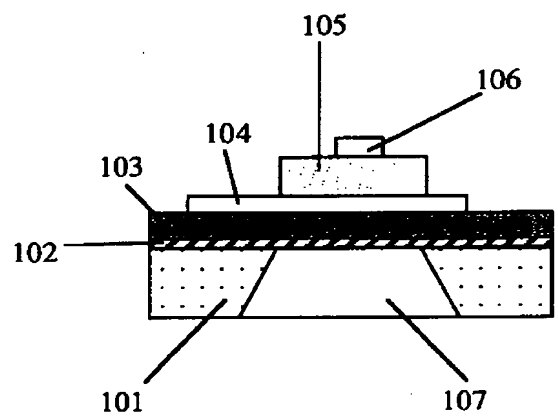
(54)【発明の名称】圧電体薄膜素子

(57)【要約】
【課題】　圧電体薄膜の性能が向上し素子の信頼性が高い圧電体薄膜素子を提供する。
【解決手段】　基板１０１上に下地膜、電極１０４、圧電体薄膜１０５を積層してなる圧電体薄膜素子において、下地膜を複数層１０２、１０３にて構成する。これにより、各下地膜に機能を分担させて素子の性能を向上する。たとえば、下地膜とその上層の膜との密着性や圧電体薄膜の緻密性を向上できる。



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【特許請求の範囲】

【請求項１】　基板と、
基板上に順次形成した複数の下地膜と、
下地膜上に形成した、圧電体を駆動する第１電極である導電体薄膜と、
導電体薄膜上に形成した圧電体薄膜と、
圧電体薄膜上に形成した少なくとも１つの第２電極とからなる圧電体薄膜素子。

【請求項２】　基板と、
基板上に順次形成した複数の下地膜と、
下地膜上に形成した圧電体薄膜と、
圧電体薄膜の片面に形成した少なくとも１つの電極とからなる圧電体薄膜素子。

【請求項３】　上記の複数の下地膜の中の１つが、窒化シリコン、酸化シリコン、酸化タンタル、酸化アルミニウムおよび酸化マグネシウムのいずれか１つ以上を主成分とすることを特徴とした請求項１または請求項２に記載された圧電体薄膜素子。

【請求項４】　上記の圧電体薄膜がチタン酸鉛、チタン酸ジルコン酸鉛、酸化亜鉛および窒化アルミニウムのいずれか１つ以上を主成分とすることを特徴とする請求項１から請求項３のいずれかに記載された圧電体薄膜素子。

【請求項５】　上記の導電体薄膜がチタン並びに白金、イリジウム、ルテニウム及び酸化ルテニウムのなかの少なくとも１つを主成分とすることを特徴とする請求項１から請求項４のいずれかに記載された圧電体薄膜素子。

【請求項６】　上記の基板が単結晶シリコンまたは単結晶ガリウム砒素からなることを特徴とする請求項１から請求項５のいずれかに記載された圧電体薄膜素子。

【請求項７】　上記の基板が圧電体薄膜の少なくとも振動部に接する部分を除去した形状を有することを特徴とする請求項１に記載された圧電体薄膜素子。

【請求項８】　基板が単結晶シリコンからなり、上記の複数の下地膜の中の基板に接する下地膜が窒化シリコンを主成分とし、導電体薄膜に接する下地膜が酸化シリコンを主成分とし、導電体薄膜がチタン及び白金を主成分とし、圧電体薄膜がチタン酸鉛を主成分とすることを特徴とする請求項７に記載された圧電体薄膜素子。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、通信用フィルタ、各種センサなどの広範な分野で用いられている圧電体薄膜を応用した素子に関する。

【０００２】

【従来の技術】圧電現象を応用した素子は広範な分野で用いられている。圧電体薄膜を用いた素子は、基板上に、主に圧電体薄膜と、圧電体を駆動する電極を形成したものである。必要によってはさらに基板上に下地膜を加えて、素子の特性を向上する。このような圧電体薄膜

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素子は次のようにして製造される。半導体単結晶などの基板上に種々の薄膜形成方法にて誘電体薄膜または導電体薄膜からなる下地膜を形成する。下地膜上に圧電体薄膜を形成し、さらに必要に応じて上部構造を形成する。各層の形成後に、または全層を形成した後に、各膜に物理的処理または化学的処理を施すことによりパターニングを行う。最後に１素子単位に分離することにより圧電体薄膜素子を得る。特に圧電体薄膜のバルク振動による超音波を利用する素子の場合には、圧電体薄膜の振動を容易にするために、基板から振動部の下に位置する部分を除去した浮き構造を採用している。たとえば、特開平６-３５０１５４号公報に記載された圧電体薄膜素子は、基板上に下地膜、下部電極、圧電体薄膜、上部電極を形成した後で、基板裏面から振動部となる部分の下にある基板部分を除去する。

【０００３】

【発明が解決しようとする課題】ところで、圧電体薄膜を応用した素子において、下地膜は、素子の特性を向上させるために用いられる。下地膜に対しては、素子特性及び信頼性の上で電気的絶縁性、機械的強度、引張応力、上部構造、例えば電極膜との良好な密着性、雰囲気に対する化学的安定性などの多くの機能を有していることが必要とされる。たとえば、下地膜は、圧電体の音響損失を生じるものであってはならないし、また、圧電体に応力を生じるものであってはならない。また、素子の製造、使用環境において化学的に安定でなければならない。しかし、全ての要求を満足させ得る下地膜を得ることはきわめて困難であった。また、圧電体薄膜素子において浮き構造を形成するためには、多くの場合、基板の裏面から基板をエッチングするプロセスがとられる。下地膜にはこのエッチングプロセスに耐える化学的安定性が必要となる。下地膜に高いプロセス耐性を求め、これを優先した場合には、下地膜の主成分が限定される。しかし、プロセス耐性を優先させた下地膜を用いた場合には、エッチングプロセスの安定性は増大する一方で、導電体薄膜及び圧電体薄膜に対する密着性、またはこれらの膜の高品質形成を促す特性に必ずしも十分ではない。

【０００４】本発明の目的は、圧電体薄膜の性能が向上し素子の信頼性が高い圧電体薄膜素子を提供することである。

【０００５】

【課題を解決するための手段】本発明に係る第１の圧電体薄膜素子は、基板と、基板上に順次形成した複数の下地膜と、下地膜上に形成した、圧電体を駆動する第１電極である導電体薄膜と、導電体薄膜上に形成した圧電体薄膜と、圧電体薄膜上に形成した少なくとも１つの第２電極とからなる。また、本発明に係る第２の圧電体薄膜素子は、基板と、基板上に順次形成した複数の下地膜と、下地膜上に形成した圧電体薄膜と、圧電体薄膜の片面に形成した少なくとも１つの電極とからなる。好まし

くは、上記の複数の下地膜の１つが、窒化シリコン、酸化シリコン、酸化タンタル、酸化アルミニウムおよび酸化マグネシウムのいずれか１つ以上を主成分とする。また、好ましくは、上記の圧電体薄膜がチタン酸鉛、チタン酸ジルコン酸鉛、酸化亜鉛および窒化アルミニウムのいずれか１つ以上を主成分とすることを特徴とする。また、好ましくは、上記の導電体薄膜がチタン並びに白金、イリジウム、ルテニウム及び酸化ルテニウムのなかの少なくとも１つを主成分とする。また、好ましくは、上記の基板が単結晶シリコンまたは単結晶ガリウム砒素からなる。また、好ましくは、上記の基板が圧電体薄膜の少なくとも振動部に接する部分を除去した形状を有する。ここで、好ましくは、基板が単結晶シリコンからなり、上記の複数の下地膜のなかの基板に接する下地膜が窒化シリコンを主成分とし、導電体薄膜に接する下地膜が酸化シリコンを主成分とし、導電体薄膜がチタン及び白金を主成分とし、圧電体薄膜がチタン酸鉛を主成分とする。

【０００６】

【発明の実施の形態】本発明に係る第１の圧電体薄膜素子は、基板と、基板上に順次形成した複数の下地膜と、下地膜上に形成した、圧電体を駆動する第１電極（下部電極）である導電体薄膜と、導電体薄膜上に形成した圧電体薄膜と、圧電体薄膜上に形成した少なくとも１つの第２電極（上部電極）とからなる。この圧電体薄膜素子は、たとえば共振器、フィルタ、発振器である。電圧制御発振器は、共振器と電圧発生回路と組み合わせることにより構成できる。また、フィルタとしては、複数の電極を組み合わせることにより、最低１対の電極の組み合わせで特定の周波数の濾波や除去を行うフィルタを形成でき、複数対の電極を組み合わせることにより多段接続フィルタを形成できる。

【０００７】また、本発明に係る第２の圧電体薄膜素子は、基板と、基板上に順次形成した複数の下地膜と、圧電体薄膜の片面に形成した少なくとも１つの電極とからなる。この圧電体薄膜素子は、たとえば圧電体表面に２つの櫛形電極を形成した弾性表面波素子である。

【０００８】これらの圧電体薄膜素子では、下地膜を複数層により構成するので、それぞれの下地膜がその機能を分担でき、素子諸特性に対する最適構成が実現される。このような構造をとることは、圧電体薄膜の性能の高品質化、素子の信頼性向上に有効であり、また、歩留まりを向上できる。たとえば、２層の下地膜を用いる場合、基板上に形成する化学的に安定な第１下地膜の上に、第１下地膜よりも緻密性、導電体薄膜または圧電体薄膜などとの密着性、これらの膜の高品質化を促す特性などに優れた第２下地膜を形成することによって、下地膜に要求される特性を満足し得る構成を実現する。これにより、高性能かつプロセス安定性に優れ、信頼性及び歩留まりの高い圧電体薄膜素子を提供する。また、３層の下地膜を用いる場合、導電体薄膜からなる下部電極または圧電体薄膜に接する第３下地膜として、密着性に優れた膜を用いることにより下地膜とその上層の膜との密着性に優れた圧電体薄膜素子を提供する。

【０００９】また、電極などとの密着性や、上部の構成膜の高品質化をサポートする材質としては、平滑性を重視すれば、酸化シリコン、窒化シリコンなどが好ましく、結晶性、配向性を重視すれば酸化マグネシウム、酸化アルミニウムなどを挙げることができる。

【００１０】さらに、応力調整を必要とする場合には、一般的な膜は圧縮応力が存在するため、これを相殺するために引張応力を有する窒化シリコンまたは酸化タンタルなどが有効である。これらの膜はその応用状況により適切に組み合わせて適用を行う。

【００１１】ここで、「圧電体」の用語は、圧電現象を生ずる材料全てを指すものとして用いており、電気信号を機械振動に変換する機能またはこの逆機能を主として用いている材料種にのみ限定するものではない。従って、ここで記述した圧電体の中には、強誘電性、焦電性を主体とした機能を持つ材料として応用されている材料種をも含む。

【００１２】また、適用し得る圧電体薄膜としても特に制限はなく、ニオブ酸リチウム、水晶、チタン酸ビスマス、ニオブ酸カリウムなど多くが挙げられる。中でも、チタン酸ジルコン酸鉛、チタン酸鉛、酸化亜鉛、窒化アルミニウムなどが形成温度などから薄膜形成が容易であり好適である。

【００１３】これらの圧電体薄膜を作製する上で導電性薄膜電極材として、成膜環境において安定なＰｔ、Ｉｒ、Ｒｕ、RuO_2、IrO_2、$SrRuO_2$、または、これらとＴｉ、Ｃｒ、Ｔａ、Ｗ、Ｚｒ、Ｎｂなどを密着層として組み合わせた２層構成が良好である。特に、化学的に最も安定で抵抗の低いＰｔ、Ｉｒ、Ｒｕ及びRuO_2のなかの少なくとも１つと強い密着性を示すＴｉとの組み合わせが好適である。

【００１４】上記の浮き構造を有する素子構造の場合には、基板除去を必要とするので、基板に接する下部下地膜は、化学的に安定で耐エッチング性に優れた膜であり、また、その上に形成される上部下地膜は、その上部の構成を構造上、特性上サポートし得る膜となる。この場合、上部下地膜の形成により下部下地膜の変質が生じる場合には、両下地膜の中間の下地膜として、反応抑制層を挟むことが有効である。また、構造体全体の残留応力による変形が問題となる場合には、上部層、下部層または中間層を応力調整層として用いることもきわめて有効である。このような下地膜として最適な材質としては、上述の浮き構造形成に多用されるアルカリ溶液に対する耐性を必要とされるため、窒化シリコン、熱酸化シリコン、酸化タンタル、酸化マグネシウム、酸化アルミニウムなどを挙げることができる。

【００１５】浮き構造を有する素子を作製する上では、アルカリ溶液による基板エッチングが有効である。この際に、基板にシリコン単結晶またはガリウムヒ素単結晶を用いることは、周辺素子との集積性または豊富な既存のプロセスデータを利用できるという点で有効である。

【００１６】特に浮き構造を有する素子は、圧電共振を応用する素子に対して基板部への振動エネルギーの漏出を防止できるため、極めて有効である。圧電共振を利用する素子の具体的構成としては、シリコン単結晶、窒化シリコン、酸化シリコン、白金／チタン及びチタン酸鉛が優れた特性を有する組み合わせとして挙げることができる。また、これらの素子の共振部と共振部外部との電気的接続をエアブリッジによる空中配線により行えば、表面配線を行った場合に発生する寄生容量の増大の防止、高段差配線による断線防止に対し有効である。

【００１７】以下、添付の図面を参照して本発明を実施の形態により具体的に説明する。なお、図面において、同じ参照記号は同一または同等のものを示す。

【００１８】図１は、本発明の第１の実施の形態の第１例における圧電体薄膜素子の構造を図式的に示す。この圧電体薄膜素子は、圧電体薄膜と導電体薄膜からなる共振部を有する共振器である。まず、Ｓｉ単結晶基板１０１上にSiN_xからなる下部下地膜１０２を形成した。成膜方法にはｐ－ＣＶＤ法を用い、膜厚を１００ｎｍとした。反応ガスにはSiH_4、NH_3及び窒素を用いた。SiH_4とNH_3の流量比を制御してSiN_x膜が引張応力を持つようにした。成膜時の基板温度を３５０℃とした。

【００１９】次に、下部下地膜１０２上に、SiO_2からなる上部下地膜１０３を形成した。成膜方法はｐ－ＣＶＤ法を用い、原料にはＴＥＯＳを用いた。膜厚を２μｍとした。成膜時の基板温度を３００℃とした。下地膜の形成手法には特に制限はないが、ＣＶＤ法は、条件変更による応力調整の容易さ、厚い膜厚が必要な場合にも容易に実現できること、それを実現する成膜速度の速さ、スループットの高さから、特に有効である。ここで、下地膜１０２、１０３内に吸蔵した残留反応ガスを放出させるために１０００℃、3時間、N_2雰囲気中にてベーキングを行った。

【００２０】その後、上部下地膜１０３上に、下部電極１０４としてＰｔ／Ｔｉ膜を形成した。ＴｉはSiO_2膜とＰｔとの間の密着層として形成した。膜厚はＴｉ：５０ｎｍ、Ｐｔ:１５０ｎｍとした。成膜はＲＦマグネトロンスパッタ法を用い、スパッタガスにはＡｒを使用した。成膜時の温度は６００℃とした。

【００２１】次に、下部電極１０４上に$PtTiO_3$を形成して圧電体薄膜１０５を形成した。成膜方法にはＲＦマグネトロンスパッタ法を用いた。成膜時の基板温度は６００℃、スパッタガスにはＡｒとO_2の混合ガスを用いた。圧電体薄膜１０５の膜厚を１μｍとした。

【００２２】次に、圧電体薄膜１０５の上にＰｔ／Ｔｉ膜からなる上部電極１０６を形成した。上部電極１０６は蒸着法により形成し、リフトオフ法により所定形状に形成した。ここでは１００μｍ＊１００μｍの形状とした。上部電極１０６の膜厚はＰｔ:７０ｎｍ、Ｔｉ:３０ｎｍとした。基板温度２５℃で成膜を行った。

【００２３】次に、基板表面をガラスとワックスによりカバーして、基板１０１において、上部電極１０６を形成した部分に対応する部分を裏面から湿式エッチングにより完全に除去した。これにより、基板１０１から圧電体薄膜の少なくとも振動部に接する部分を除去した。エッチング液には５wt%ＫＯＨ水溶液を用い、液温７０℃にて異方性エッチングを行い、バイアホール１０７を形成した。基板が完全に溶解された際、下地膜１０２によりエッチングを停止することができた。こうして、圧電体薄膜素子を作製した。

【００２４】図２は、作製した圧電体薄膜素子の断面を走査電子顕微鏡（ＳＥＭ）で観察した像を示す。図２から、上部下地膜１０３の存在により緻密な圧電体薄膜を形成できたことがわかる。また、上部下地膜１０３と下部電極（Ｔｉ）１０４の間で剥離や膨れの発生がなく、密着性に優れていることがわかる。

【００２５】次に、１層の下地層を用いた第１比較例を説明する。図３は、第１比較例において作製した圧電体薄膜素子の図式的な断面図を示す。基板１０１上にSiN_xからなる下地膜１０２を形成し、下地膜１０２上にＰｔ/Ｔｉ膜からなる下部電極１０４を形成した。下地膜１０３を形成しないこと以外は全て上述の実施の形態と同様にして圧電体薄膜素子を作製した。

【００２６】図４に、得られた圧電体薄膜の断面のＳＥＭ像を示す。第１比較例の圧電体薄膜は、第１の実施の形態の素子の圧電体薄膜を示す図２と比較して、緻密でないことが明らかである。しかも、図５において、矢印で示すような膨れ１１０を発生した。この膨れ１１０はSiN_x膜からなる下地膜１０２とＴｉの密着性が良くないために発生したものである。

【００２７】次に、本発明の第１の実施の形態における圧電体薄膜素子の第２例について説明する。Ｓｉ単結晶基板１０１上にSiN_x膜からなる下部下地膜１０２を膜厚１００ｎｍ形成した。下部下地膜１０２上に、ＲＦマグネトロンスパッタ法によりAl_2O_3からなる上部下地膜１０３を２００ｎｍ形成した。ターゲットにはＡｌを用い、反応ガスにはNH_3、O_2、N_2及びＡｒの混合ガスを用いた。成膜温度は３００℃とした。その他の作製方法は第１例と同様にして圧電体薄膜素子を作製した。走査電子顕微鏡により圧電体薄膜の断面を観察した。図示しないが、剥離もなく緻密な圧電体薄膜を形成していることが判った。

【００２８】次に、本発明の第１の実施の形態における圧電体薄膜素子の第３例について説明する。Ｓｉ単結晶

基板１０１上に、ＳｉＯ$_2$膜からなる下部下地膜１０２を膜厚２００ｎｍ形成した。下部下地膜１０２上にＲＦマグネトロンスパッタ法によりＭｇＯからなる上部下地膜１０３を５００ｎｍ形成した。ターゲットにはＭｇを用い、反応ガスにはＯ$_2$とＡｒの混合ガスを用いた。成膜温度は３００℃とした。その他の作製方法は第１例と同様にして圧電体薄膜素子を作製した。走査電子顕微鏡により圧電体薄膜の断面を観察した。図示しないが、下地膜１０３と下部電極１０４の間の密着性はよく、緻密な圧電体薄膜を形成していること判った。

【００２９】次に、本発明の第１の実施の形態における第４例の圧電体薄膜素子について説明する。ＧａＡｓ単結晶基板を用いて、裏面から基板に対し硫酸系エッチング液により等方エッチングを行った。他の作製方法は、第１の実施の形態と同様に行い圧電体薄膜素子を作製した。図示しないが、得られた圧電体薄膜素子は、下地膜１０３と下部電極１０４間の密着性はよく、緻密な圧電体薄膜を形成していることが判った。また、下地膜１０３が引張応力を持ち、応力調整の効果があることが判った。

【００３０】次に、第２の比較例における圧電体薄膜素子について説明する。ＧａＡｓ単結晶基板を用いて、ＳｉＯ$_2$からなる下地膜１０２を１００ｎｍ形成した。他は第１の実施の形態の第４例と同様に圧電体薄膜素子を作製した。下地膜１０２と下部電極１０４間で剥離は生じなかったが、圧電体薄膜は第１比較例と同様に緻密ではないことが判った。さらに、下地膜１０２、下部電極１０４及び圧電体薄膜１０５の内部応力が全て同方向であることから、基板に多大な応力が加わったため基板が変形し、素子信頼性に劣るという問題が生じた。

【００３１】本発明の第１の実施の形態における圧電体薄膜素子の第５例について説明する。第１例と同様に、下地膜１０２、１０３を形成した後、Ｉｒ／Ｔｉからなる下部電極１０４を形成した。下部電極の形成方法はＲＦマグネトロンスパッタ法で行い、基板温度３００℃にて、Ａｒガスを用いた。各膜厚をＩｒ:２００nm、Ｔｉ:５０ｎｍとした。さらに、上部電極にはＡｕ／Ｔｉ膜を用いた。膜厚はＡｕ:７０ｎｍ、Ｔｉ:３０ｎｍとした。成膜方法は蒸着法を用いた。圧電体薄膜形成工程、基板エッチング工程などは全て第１の実施の形態の第１例と同様に行い、圧電体薄膜素子を作製した。図示しないが、下地膜１０３と下部電極１０４間に剥離は生じなかった。また、緻密な圧電体薄膜を得られていることが判った。

【００３２】本発明の第１の実施の形態における圧電体薄膜素子の第６例について説明する。第１例と同様に下地膜１０２、１０３を形成した後、Ｐｔ／Ｔｉからなる下部電極１０４を形成した。下部電極の形成方法はＲＦマグネトロンスパッタ法で行い、基板温度６００℃、Ａｒガスを用いた。各膜厚をＰｔ:１５０ｎｍ、Ｔｉ:３０ｎｍとした。さらに、上部電極にはＡｕ／Ｔｉ膜を用いた。膜厚はＡｕ:７０ｎｍ、Ｔｉ:３０ｎｍとした。成膜方法は蒸着法を用いた。圧電体薄膜形成工程、基板エッチング工程などは全て第１例と同様に行い、圧電体薄膜素子を作製した。図示しないが、下地膜１０３と下部電極１０４間に剥離は生じなかった。また、緻密な圧電体薄膜を得られていることが判った。

【００３３】本発明の第１の実施の形態における圧電体薄膜素子の第７例について説明する。第１例と同様に下地膜１０２、１０３を形成した後、ＲｕＯ$_2$からなる下部電極１０４を形成した。下部電極の形成方法はＲＦマグネトロンスパッタ法で行い、基板温度３００℃、ＡｒとＯ$_2$の混合ガスを用い、膜厚を１００ｎｍとした。さらに、上部電極にはＡｌ膜を用いた。膜厚は１０ｎｍとした。成膜方法は蒸着法を用いた。圧電体薄膜形成工程、基板エッチング工程などは全て第１例と同様に行い、圧電体薄膜素子を作製した。図示しないが、下地膜１０３と下部電極１０４の間に剥離は生じなかった。また、緻密な圧電体薄膜を得られていることが判った。

【００３４】本発明の第１の実施の形態における圧電体薄膜素子の第８例について説明する。第１例と同様にＳｉ単結晶基板１０１上に下地膜１０２、１０３、下部電極１０４を形成した後、ＰＺＴからなる圧電体薄膜１０５をＲＦマグネトロンスパッタ法により形成した。圧電体薄膜１０５はＰＺＴの焼結体をターゲットとして用い、ＡｒとＯ$_2$の混合ガス、基板温度６５０℃、膜厚８００ｎｍに成膜した。上部電極１０６およびＳｉ基板のエッチングを第１例と同様に行い、圧電体薄膜素子を作製した。図示しないが、下地膜１０３と下部電極１０４との間の密着性は良好であり、また、緻密な圧電体薄膜１０５が得られた。

【００３５】本発明の第１の実施の形態における圧電体薄膜素子の第９例について説明する。第８例と同様に圧電体薄膜素子を作製した。ここで、圧電体薄膜１０５にはＺｎＯ薄膜を用いた。ＺｎＯ薄膜はＲＦマグネトロンスパッタ法にて形成した。ターゲットにはＺｎを用い、スパッタガスにはＯ$_2$を用いた。基板温度は５００℃、膜厚は５μｍとした。その結果、下地膜１０３と下部電極１０４との間の密着性は良好であり、また、緻密な圧電体薄膜１０５が得られた。

【００３６】本発明の第１の実施の形態における圧電体薄膜素子の第１０例について説明する。第９例と同様に圧電体薄膜素子を作製した。ここで、圧電体薄膜１０５にはＡｌＮ薄膜を用いた。ＡｌＮ薄膜はＲＦマグネトロンスパッタにより形成した。ターゲットにはＡｌを用い、Ｎ$_2$をスパッタガスとし、基板温度６００℃、膜厚を１μｍとした。図示しないが、下地膜１０３と下部電極１０４との間の密着性は良好であり、また、緻密な圧電体薄膜１０５が得られた。

【００３７】次に、本発明の第２の実施の形態における

フィルタについて説明する。図６は、作製したフィルタの構造を示す。このフィルタの作成において、Ｓｉ単結晶基板１０１上に、第１の実施の形態の第１例と同様に、２層の下地膜１０２、１０３、下部電極１０４及び圧電体薄膜１０５を形成した。上部電極１０６の形状を２０μｍ＊１００μｍとして２個並列させた。上部電極１０６の成膜条件は第１例と同様にした。各々の上部電極１０６からＡｕ／Ｔｉメッキにより形成したエアブリッジ１０８を用いて、電極取り出し用パッド１０９と接続させて入出力用電極とした。Ｓｉ単結晶基板１０１の裏面を第１例と同様に異方性エッチングにて溶解した。こうして、圧電体薄膜素子を応用したフィルタを作製した。その結果、下地膜１０２にてエッチングを停止することができ、下地膜１０３と下部電極１０４との密着性は良好であり、かつ、緻密な圧電体薄膜１０５を得ることができた。

【００３８】前記の第１の実施の形態の第１例において示した共振器と第１比較例において作製した共振器より測定された共振器の圧電膜のＱ値を測定値より解析したところ、前者が２２０であったのに対し、後者は６５であった。ここで示したＱ値とは、弾性波の伝搬の際に生じる損失の大きさを表す指標であり、Ｑ＝１／損失の式で表され、数値が大きいほど、低損失であることを意味する。このように、化学的に安定な下部下地膜１０２以外に、緻密でかつ音響的損失の少ない材質の上部下地膜１０３を持ち、複数層からなる下地膜を形成することにより圧電体薄膜素子の音響的損失を低減できる効果もあることがわかった。

【００３９】次に、本発明の第３の実施の形態におけるフィルタについて説明する。図７は、作製したフィルタの構造を示す。まず、Ｓｉ単結晶基板１０１上に、SiN_x膜からなる下部下地膜１０２を膜厚１００ｎｍに形成した。下部下地膜１０２上にＡｌＮからなる中間下地膜１０３を膜厚２μｍに形成した。ここで、下部下地膜１０２は第１の実施の形態の第１例と同様の方法にて形成した。中間下地膜１０３の形成方法はＲＦマグネトロンスパッタ法により、Ａｌターゲットを使用した。基板温度を６５０℃、スパッタガスとしてＡｒとO_2の混合ガスを用いた。さらに中間下地膜１０３上にSiO_2からなる上部下地膜１１１を膜厚２．５μｍに形成した。上部下地膜１１１は第１の実施の形態の第１例と同様の方法で形成した。下地膜１１１上に第２の実施の形態と同様に各膜を積層してフィルタを作製した。その結果、第２の実施の形態と同様に、緻密な圧電体薄膜を持ち、音響的損失の少ない特性を持つフィルタが得られた。

【００４０】本発明の第４の実施の形態における弾性表面波素子について説明する。図８は、弾性表面波素子の構造を示す。まず、Ｓｉ単結晶基板１０１上に、SiN_xからなる下部下地膜１０２と、SiO_2からなる上部下地膜１０３を第１の実施の形態の第１例と同様の方法で形成した。次に、上部下地膜１０３上に$PtTiO_3$を形成して圧電体薄膜１０５を形成した。次に、圧電体薄膜１０５の上にＰｔ／Ｔｉからなる交差指電極１１４、１１５を形成した。こうして、圧電体薄膜素子を作製した。

【００４１】なお、第１の実施の形態では共振器について説明し、第２と第３の実施の形態ではフィルタについて説明し、第４の実施の形態では弾性表面波素子について説明したが、本発明は電極の構成により他の種々の素子へも適用可能である。

【００４２】

【発明の効果】本発明に係る第１の圧電体薄膜素子は、基板と、基板上に順次形成した複数の下地膜と、下地膜上に形成した、圧電体を駆動する第１電極である導電体薄膜と、導電体薄膜上に形成した圧電体薄膜と、圧電体薄膜上に形成した少なくとも１つの第２電極とからなり、また、本発明に係る第２の圧電体薄膜素子は、基板と、基板上に順次形成した複数の下地膜と、下地膜上に形成した圧電体薄膜と、圧電体薄膜の片面に形成した少なくとも１つの電極とからなる。すなわち、下地膜が複数層にて構成される。これにより、下地膜とその上層の膜の間の密着性と圧電体薄膜の品質を向上できた。また、圧電体薄膜を緻密化したことや圧電体薄膜に接する下地膜が緻密であることから圧電体薄膜素子の音響的損失が低減されるという新たな効果が得られる。また、各下地膜の残留応力を調整することにより圧電体薄膜素子全体の残留応力を調整できる。その結果、圧電体薄膜素子の性能、信頼性及び歩留まりを飛躍的に向上できた。

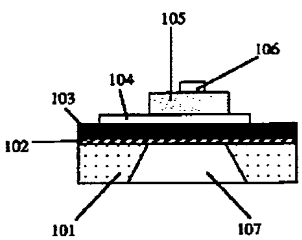
【００４３】下地膜の１つが窒化シリコン、酸化シリコン、酸化タンタル、酸化アルミニウムおよび酸化マグネシウムのいずれか１つ以上を主成分とするので、下地膜のアルカリ溶液に対する耐性が高い。また、圧電体薄膜がチタン酸鉛、チタン酸ジルコン酸鉛、酸化亜鉛および窒化アルミニウムのいずれか１つ以上を主成分とするので、薄膜作成が容易である。また、導電体薄膜がチタン並びに白金、イリジウム、ルテニウム及び酸化ルテニウムのなかの少なくとも１つを主成分とするので、導電体薄膜は、化学的に安定であり、かつ、密着性にすぐれる。また、基板が単結晶シリコンまたは単結晶ガリウム砒素からなるので、種々の特性の下地膜が選択できる。また、上記の基板が圧電体薄膜の少なくとも振動部に接する部分を除去した形状を有するので、この形状により基板部への振動エネルギーの漏出を防止する。また、基板が単結晶シリコンからなり、複数の下地膜のなかの基板に接する下地膜が窒化シリコンを主成分とし、導電体薄膜に接する下地膜が酸化シリコンを主成分とし、導電体薄膜がチタン及び白金を主成分とし、圧電体薄膜がチタン酸鉛を主成分とするので、基板に接する下地膜を化学的に安定な膜として、性能の優れた素子が得られる。

【図面の簡単な説明】

【図１】　本発明の第１の実施形態における発振器の図式的断面図である。
【図２】　この圧電体薄膜素子における圧電体薄膜の断面ＳＥＭ像の図である。
【図３】　第１比較例における圧電体薄膜素子の構造を示す図式的断面図である。
【図４】　この圧電体薄膜素子における圧電体薄膜素子の断面ＳＥＭ像の図である。
【図５】　第２比較例の圧電体薄膜素子の断面ＳＥＭ像の図である。
【図６】　本発明の第２実施形態のフィルタの図式的平面図である。

【図７】　本発明の第３実施形態のフィルタの図式的断面図である。
【図８】　本発明の第４実施形態の弾性表面波素子の図式的断面図である。
【符号の説明】
１０１　基板、　１０２　下地膜、　１０３　下地膜、　１０４　下部電極、　１０５　圧電体薄膜、　１０６、１０６’　上部電極、１０７　バイアホール、　１０８　エアブリッジ、　１０９　パッド、　１１０　剥離、　１１１　下地膜、　１１４、１１５　電極。

【図１】



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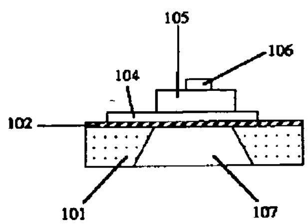

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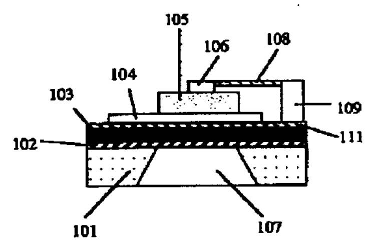

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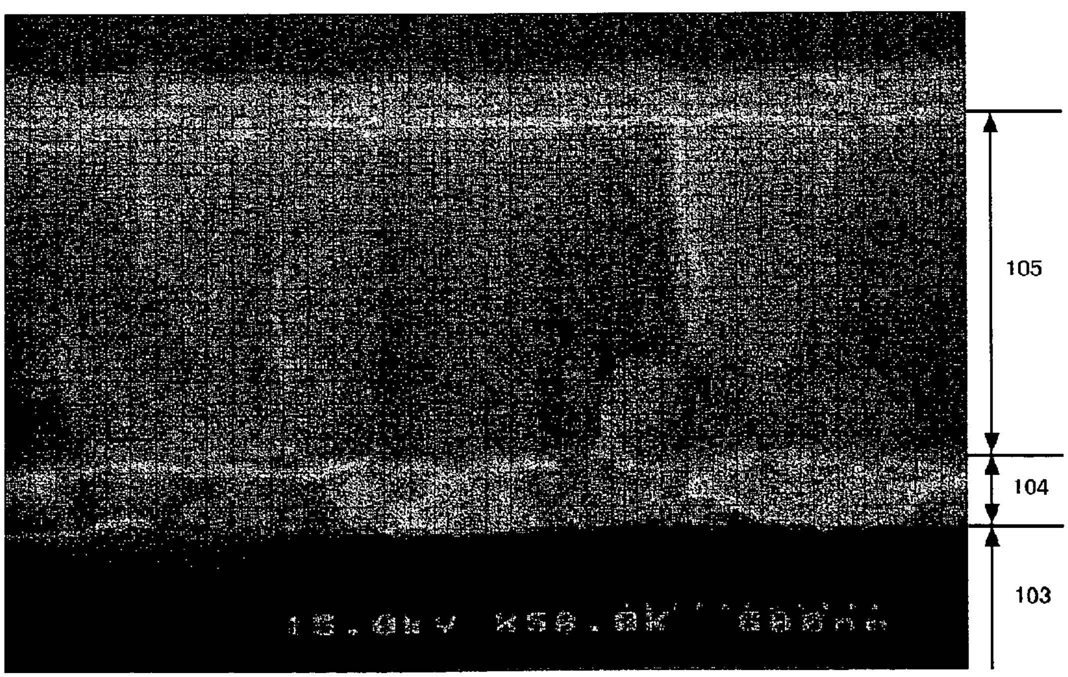
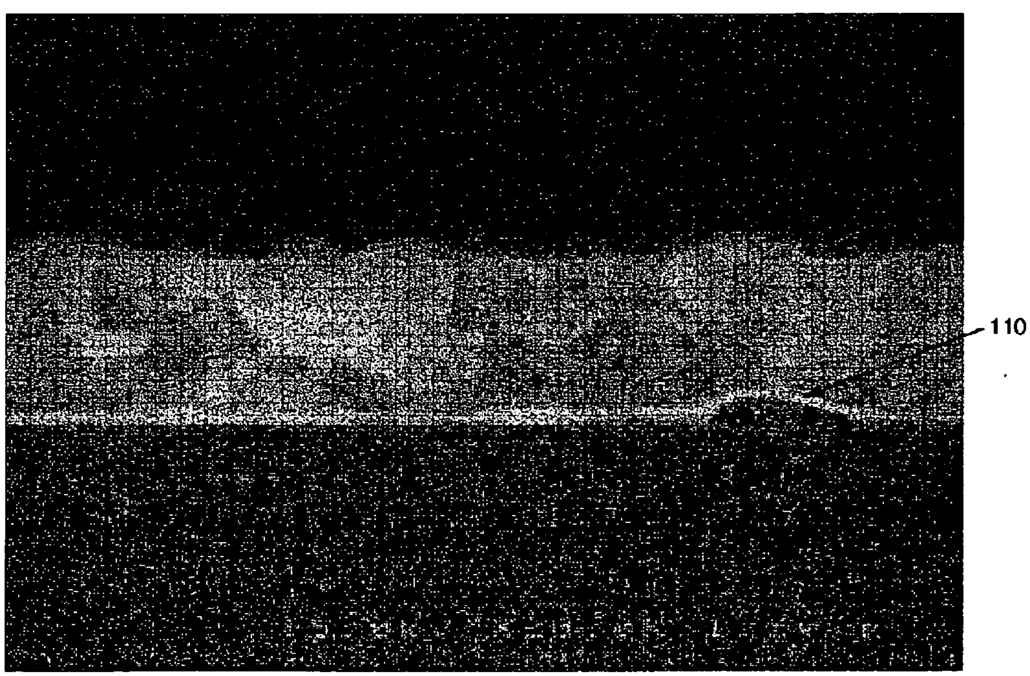
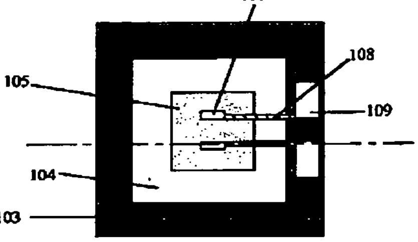


【図４】

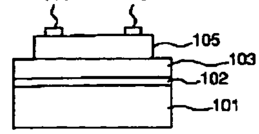
【図５】



【図６】



【図８】



フロントページの続き

(72)発明者　内川　英興
東京都千代田区丸の内二丁目２番３号　三菱電機株式会社内

(72)発明者　三須　幸一郎
東京都千代田区丸の内二丁目２番３号　三菱電機株式会社内

(72)発明者　和高　修三
東京都千代田区丸の内二丁目２番３号　三菱電機株式会社内

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Bibliography

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(71) [Applicant]
[Identification Number] 000006013
[Name] Mitsubishi Electric Corp.
[Address] 2-2-3, Marunouchi, Chiyoda-ku, Tokyo
(72) [Inventor(s)]
[Name] Maeda ******
[Address] 2-2-3, Marunouchi, Chiyoda-ku, Tokyo Inside of Mitsubishi Electric Corp.
(72) [Inventor(s)]
[Name] Yamada **
[Address] 2-2-3, Marunouchi, Chiyoda-ku, Tokyo Inside of Mitsubishi Electric Corp.
(72) [Inventor(s)]

[Name] Uchikawa Hidefusa
[Address] 2-2-3, Marunouchi, Chiyoda-ku, Tokyo Inside of Mitsubishi Electric Corp.
(72) [Inventor(s)]
[Name] Misu Koichiro
[Address] 2-2-3, Marunouchi, Chiyoda-ku, Tokyo Inside of Mitsubishi Electric Corp.
(72) [Inventor(s)]
[Name] Sum quantity Shuuzo
[Address] 2-2-3, Marunouchi, Chiyoda-ku, Tokyo Inside of Mitsubishi Electric Corp.
(74) [Attorney]
[Identification Number] 100062144
[Patent Attorney]
[Name] Aoyama ** (outside binary name)
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Epitome

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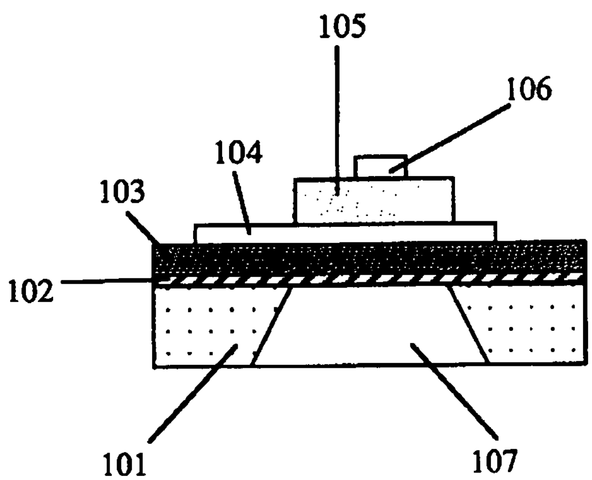
(57) [Abstract]
[Technical problem] The engine performance of a piezo electric crystal thin film improves, and a piezo electric crystal thin film with the high dependability of a component is offered.
[Means for Solution] In the piezo electric crystal thin film which comes to carry out the laminating of the substrate film, an electrode 104, and

the piezo electric crystal thin film 105 on a substrate 101, the two or more layers substrate film consists of 102 and 103. Thereby, a function is made to share with each substrate film, and the engine performance of a component is improved. For example, the adhesion of the substrate film and the film of the upper layer and the compactness of a piezo electric crystal thin film can be improved.

[Translation done.]



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CLAIMS

[Claim(s)]
[Claim 1] The piezo electric crystal thin film which consists of a substrate, two or more substrate film which carried out sequential formation on the substrate, the conductor thin film which is the 1st

electrode which was formed on the substrate film, and which drives a piezo electric crystal, a piezo electric crystal thin film formed on the conductor thin film, and 2nd at least one electrode formed on the piezo electric crystal thin film.

[Claim 2] The piezo electric crystal thin film which consists of at least one electrode formed on the substrate and the substrate at one side of two or more substrate film which carried out sequential formation, the piezo electric crystal thin film formed on the substrate film, and a piezo electric crystal thin film.

[Claim 3] The piezo electric crystal thin film indicated by claim 1 or claim 2 to which one in two or more above-mentioned substrate film was characterized by using any one or more of silicon nitride, silicon oxide, tantalum oxide, an aluminum oxide, and the magnesium oxides as a principal component.

[Claim 4] The piezo electric crystal thin film indicated by either of claim 1 to claims 3 characterized by the above-mentioned piezo electric crystal thin film using any one or more of lead titanate, titanic-acid lead zirconate, a zinc oxide, and the alumimium nitride as a principal component.

[Claim 5] The piezo electric crystal thin film indicated by either of claim 1 to claims 4 characterized by the above-mentioned conductor thin film using at least one in platinum, iridium, a ruthenium, and ruthenium oxide as a principal component at a titanium list.

[Claim 6] The piezo electric crystal thin film indicated by either of claim 1 to claims 5 characterized by the above-mentioned substrate consisting of single crystal silicon or single crystal gallium arsenide.

[Claim 7] The piezo electric crystal thin film indicated by claim 1 to which the above-mentioned substrate is characterized by having the configuration where the part of a piezo electric crystal thin film which touches the oscillating section at least was removed.

[Claim 8] The piezo electric crystal thin film indicated by claim 7 which the substrate film which touches the substrate in two or more above-mentioned substrate film by a substrate consisting of single crystal silicon uses silicon nitride as a principal component, and is characterized by for the substrate film which touches a conductor thin film using silicon oxide as a principal component, for a conductor thin film using titanium and platinum as a principal component, and a piezo electric crystal thin film using lead titanate as a principal component.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the component adapting the piezo electric crystal thin film used in extensive fields, such as a filter for a communication link, and various sensors.

[0002]

[Description of the Prior Art] The component adapting piezoelectric phenomena is used in the extensive field. The component using a piezo electric crystal thin film mainly forms on a substrate a piezo electric crystal thin film and the electrode which drives a piezo electric crystal. Depending on the need, the substrate film is further added on a substrate, and the property of a component is improved. Such a piezo electric crystal thin film is manufactured as follows. The substrate film which consists of a dielectric thin film or a conductor thin film by the various thin film formation approaches is formed on substrates, such as a semi-conductor single crystal. A piezo electric crystal thin film is formed on the substrate film, and a superstructure is formed further if needed. After formation of each class, or after forming all layers, patterning is performed by performing physical processing or chemical preparation to each film. A piezo electric crystal thin film is obtained by finally dissociating per one element. In the case of the component which uses the supersonic wave by bulk vibration of a piezo electric crystal thin film especially, in order to make easy vibration of a piezo electric crystal thin film, the floating construction which removed the part located under the oscillating section from the substrate is adopted. For example, the piezo electric crystal thin film indicated by JP,6-350154,A removes the substrate part under the part which serves as the oscillating section from a substrate rear face, after forming the substrate film, a lower electrode, a piezo electric

crystal thin film, and an up electrode on a substrate.
[0003]
[Problem(s) to be Solved by the Invention] By the way, in the component adapting a piezo electric crystal thin film, the substrate film is used in order to raise the property of a component. To the substrate film, to have many functions, such as electric insulation, a mechanical strength, tensile stress, a superstructure, for example, good adhesion with an electrode layer, and chemical stability to an ambient atmosphere, on a component property and dependability is needed. For example, the substrate film must not produce sound loss of a piezo electric crystal, and must not produce stress in a piezo electric crystal. Moreover, in manufacture of a component, and an operating environment, it must be chemically stable. However, it was very difficult to obtain the substrate film on which all demands may be satisfied. Moreover, in order to form floating construction in a piezo electric crystal thin film, in many cases, the process which etches a substrate from the rear face of a substrate is taken. The chemical stability which bears this etching process is needed for the substrate film. When the substrate film is asked for high process resistance and priority is given to this over it, the principal component of the substrate film is limited. However, when the substrate film over which priority was given to process resistance is used, while the stability of an etching process increases, it is not necessarily enough for the adhesion over a conductor thin film and a piezo electric crystal thin film, or the property to which high quality formation of these film is urged.
[0004] The purpose of this invention is the engine performance of a piezo electric crystal thin film improving, and offering a piezo electric crystal thin film with the high dependability of a component.
[0005]
[Means for Solving the Problem] The 1st piezo electric crystal thin film concerning this invention consists of a substrate, two or more substrate film which carried out sequential formation on the substrate, the conductor thin film which is the 1st electrode which was formed on the substrate film, and which drives a piezo electric crystal, a piezo electric crystal thin film formed on the conductor thin film, and 2nd at least one electrode formed on the piezo electric crystal thin film. Moreover, the 2nd piezo electric crystal thin film concerning this invention consists of at least one electrode formed on the substrate and the substrate at one side of two or more substrate film which carried out sequential formation, the piezo electric crystal thin film formed on the substrate film, and a piezo electric crystal thin film. Preferably,

one of two or more of the above-mentioned substrate film uses any one or more of silicon nitride, silicon oxide, tantalum oxide, an aluminum oxide, and the magnesium oxides as a principal component. Moreover, it is preferably characterized by the above-mentioned piezo electric crystal thin film using any one or more of lead titanate, titanic-acid lead zirconate, a zinc oxide, and the alumimium nitride as a principal component. Moreover, the above-mentioned conductor thin film uses at least one in platinum, iridium, a ruthenium, and ruthenium oxide as a principal component preferably at a titanium list. Moreover, the above-mentioned substrate consists of single crystal silicon or single crystal gallium arsenide preferably. Moreover, it has preferably the configuration where the above-mentioned substrate removed the part of a piezo electric crystal thin film which touches the oscillating section at least. Here, preferably, a substrate consists of single crystal silicon, the substrate film which touches the substrate in two or more above-mentioned substrate film uses silicon nitride as a principal component, the substrate film which touches a conductor thin film uses silicon oxide as a principal component, a conductor thin film uses titanium and platinum as a principal component, and a piezo electric crystal thin film uses lead titanate as a principal component.
[0006]
[Embodiment of the Invention] The 1st piezo electric crystal thin film concerning this invention consists of a substrate, two or more substrate film which carried out sequential formation on the substrate, the conductor thin film which is the 1st electrode (lower electrode) which was formed on the substrate film, and which drives a piezo electric crystal, a piezo electric crystal thin film formed on the conductor thin film, and 2nd at least one electrode (up electrode) formed on the piezo electric crystal thin film. This piezo electric crystal thin film is a resonator, a filter, and an oscillator. A voltage controlled oscillator can be constituted by combining with a resonator and an electrical-potential-difference generating circuit. Moreover, as a filter, by combining two or more electrodes, the filter which performs filtering and removal of a specific frequency in the combination of at least one pair of electrodes can be formed, and a multistage connection filter can be formed by combining two or more pairs of electrodes.
[0007] Moreover, the 2nd piezo electric crystal thin film concerning this invention consists of at least one electrode formed on the substrate and the substrate at one side of two or more substrate film which carried out sequential formation, and a piezo electric crystal thin film. This piezo electric crystal thin film is a surface acoustic

element in which two Kushigata electrodes were formed for example, on the piezo electric crystal front face.

[0008] In these piezo electric crystal thin films, since two or more layers constitute the substrate film, each substrate film can share the function and the optimal configuration to many component properties is realized. It is effective in quality improvement of the engine performance of a piezo electric crystal thin film, and the improvement in dependability of a component to take such structure, and it can improve the yield. For example, when using the two-layer substrate film, the configuration with which may be satisfied of the property required of the substrate film is realized by forming chemically the 2nd substrate film which excelled the 1st substrate film in adhesion with compactness, a conductor thin film, or a piezo electric crystal thin film, a property of urging quality improvement of these film, etc. which are formed on a substrate on the stable 1st substrate film. Thereby, it excels in high performance and process stability, and dependability and the high piezo electric crystal thin film of the yield are offered. Moreover, when using the substrate film of three layers, the piezo electric crystal thin film excellent in the adhesion of the substrate film and the film of the upper layer is offered by using the film excellent in adhesion as the 3rd substrate film which touches the lower electrode or piezo electric crystal thin film which consists of a conductor thin film.

[0009] Moreover, as the quality of the material which supports adhesion with an electrode etc., and quality improvement of the upside configuration film, if smooth nature is thought as important, silicon oxide, silicon nitride, etc. are desirable, and if crystallinity and a stacking tendency are thought as important, a magnesium oxide, an aluminum oxide, etc. can be mentioned.

[0010] Furthermore, since compressive stress exists, in order to offset this, silicon nitride or tantalum oxide etc. which has tensile stress is effective [the common film], when you need stress adjustment. These film applies by combining appropriately according to the application situation.

[0011] Here, the vocabulary of a "piezo electric crystal" is used as what points out all the ingredients that produce piezoelectric phenomena, and does not limit the function to change an electrical signal into mechanical vibration, or this reverse function only to the mainly used ingredient kind. Therefore, in the piezo electric crystal described here, the ingredient kind applied as an ingredient with the function which made a ferroelectricity and pyroelectricity the subject is also included.

[0012] Moreover, there is especially no limit also as a piezo electric crystal thin film which can be applied, and many, such as lithium niobate, Xtal, a titanic-acid bismuth, and a niobic acid potassium, are mentioned. Especially, formation temperature etc. to thin film formation is easy for titanic-acid lead zirconate, lead titanate, a zinc oxide, alumimium nitride, etc., and they are suitable.
[0013] The two-layer configuration which combined Ti, Cr, Ta, W, Zr, Nb, etc. with stable Pt, Ir, Ru, RuO2, IrO2 and SrRuO2, or these as an adhesion layer in the membrane formation environment as conductive thin film electrode material when producing these piezo electric crystal thin films is good. It is especially chemically the most stable and combination with Ti which shows at least one in Pt, Ir, Ru, and RuO2 with low resistance and strong adhesion is suitable.
[0014] Since substrate removal is needed in the case of the component structure of having the above-mentioned floating construction, the up substrate film which the lower substrate film which touches a substrate is chemically stable, and is film excellent in etching-proof nature, and is formed on it turns into film which can support the configuration of the upper part on structure and a property. In this case, when deterioration of the lower substrate film arises by formation of the up substrate film, it is effective as middle substrate film of both the substrates film to pinch a reaction control layer. Moreover, when deformation by the residual stress of the whole structure poses a problem, it is also very effective to use an up layer, a lower layer, or an interlayer as a stress adjustment layer. Since the resistance over the alkali solution used abundantly at above-mentioned floating construction formation is needed as the quality of the material optimal as such substrate film, silicon nitride, thermal oxidation silicon, tantalum oxide, a magnesium oxide, an aluminum oxide, etc. can be mentioned.
[0015] When producing the component which has floating construction, substrate etching by the alkali solution is effective. In this case, it is effective to use a silicon single crystal or a gallium-arsenide single crystal for a substrate at the point that accumulation nature or the abundant existing process datas with a circumference component can be used.
[0016] Since the component which has especially floating construction can prevent exsorption of the vibrational energy to the substrate section to the component adapting piezo-electric resonance, it is very effective. It can mention as a combination which has the property excellent in a silicon single crystal, silicon nitride, silicon oxide,

platinum/titanium, and lead titanate as a concrete configuration of the component using piezo-electric resonance. Moreover, if air wiring by the air bridge performs electrical installation of the resonance section of these components, and the resonance section exterior, it is effective to prevention of increase of the parasitic capacitance generated when front wiring is performed, and the open-circuit prevention by the high rank conduct-of-business line.

[0017] Hereafter, with reference to an attached drawing, the gestalt of operation explains this invention concretely. In addition, in a drawing, the same reference designator shows a same or equivalent thing.

[0018] Drawing 1 shows the structure of the piezo electric crystal thin film in the 1st example of the gestalt of operation of the 1st of this invention in graph. This piezo electric crystal thin film is a resonator which has the resonance section which consists of a piezo electric crystal thin film and a conductor thin film. First, the lower substrate film 102 which consists of SiNx was formed on Si single crystal substrate 101. Thickness was set to 100nm at the membrane formation approach using p-CVD method. SiH4, NH3, and nitrogen were used for reactant gas. The flow rate of SiH4 and NH3 is controlled, and the SiNx film had tensile stress. Substrate temperature at the time of membrane formation was made into 350 degrees C.

[0019] Next, the up substrate film 103 which consists of SiO2 was formed on the lower substrate film 102. The membrane formation approach used TEOS for the raw material using p-CVD method. Thickness was set to 2 micrometers. Substrate temperature at the time of membrane formation was made into 300 degrees C. Although there is especially no limit in the formation technique of the substrate film, the CVD method is especially effective from the speed of the membrane formation rate which realizes being easily realizable and it, and the height of a throughput, also when the ease of the stress adjustment by condition modification and thick thickness are required. Here, in order to make the residual reactant gas which carried out occlusion emit in the substrate film 102 and 103, baking was performed in N2 ambient atmosphere for 1000 degrees C and 3 hours.

[0020] Then, the Pt/Ti film was formed as a lower electrode 104 on the up substrate film 103. Ti was formed as an adhesion layer between SiO2 film and Pt. Thickness could be Ti:50nm and Pt:150nm. Membrane formation used Ar for sputtering gas using the RF magnetron sputtering method. Temperature at the time of membrane formation was made into 600 degrees C.

[0021] Next, on the lower electrode 104, PtTiO3 was formed and the piezo

electric crystal thin film 105 was formed. The RF magnetron sputtering method was used for the membrane formation approach. The substrate temperature at the time of membrane formation used the mixed gas of Ar and 02 for 600 degrees C and sputtering gas. Thickness of the piezo electric crystal thin film 105 was set to 1 micrometer.

[0022] Next, the up electrode 106 which consists of Pt/Ti film was formed on the piezo electric crystal thin film 105. The up electrode 106 was formed with vacuum deposition, and was formed in the predetermined configuration by the lift-off method. Here, it considered as the configuration of 100 micrometers * 100 micrometers. The thickness of the up electrode 106 could be Pt:70nm and Ti:30nm. Membranes were formed at the substrate temperature of 25 degrees C.

[0023] Next, the substrate front face was covered with glass and a wax, and wet etching removed completely the part corresponding to the part in which the up electrode 106 was formed from the rear face in the substrate 101. This removed the part of a piezo electric crystal thin film which touches the oscillating section at least from the substrate 101. Anisotropic etching was performed to the etching reagent at 70 degrees C of solution temperature using the 5wt%KOH water solution, and the Bahia hall 107 was formed. When a substrate was dissolved completely, etching was able to be suspended with the substrate film 102. In this way, the piezo electric crystal thin film was produced.

[0024] Drawing 2 shows the image which observed the cross section of the produced piezo electric crystal thin film with the scanning electron microscope (SEM). Drawing 2 shows that the precise piezo electric crystal thin film has been formed by existence of the up substrate film 103. Moreover, it turns out that neither exfoliation nor generating of bulging is between the up substrate film 103 and the lower electrode (Ti) 104, and it excels in adhesion.

[0025] Next, the example of the 1st comparison using an one-layer substrate layer is explained. Drawing 3 shows the graph-sectional view of the piezo electric crystal thin film produced in the example of the 1st comparison. The substrate film 102 which consists of SiNx was formed on the substrate 101, and the lower electrode 104 which consists of Pt/Ti film was formed on the substrate film 102. The piezo electric crystal thin film was produced like the gestalt of above-mentioned operation except [all] not forming the substrate film 103.

[0026] The SEM image of the cross section of the piezo electric crystal thin film obtained by drawing 4 is shown. As compared with drawing 2 which shows the piezo electric crystal thin film of the component of the gestalt of the 1st operation, it is clear that the piezo electric

crystal thin film's of the example of the 1st comparison it is not precise. And in drawing 5 , the bulging 110 as shown by the arrow head was generated. Since the adhesion of the substrate film 102 which consists of SiNx film, and Ti is not good, this bulging 110 is generated.
[0027] Next, the 2nd example of the piezo electric crystal thin film in the gestalt of operation of the 1st of this invention is explained. The lower substrate film 102 which consists of SiNx film was formed 100nm of thickness on Si single crystal substrate 101. On the lower substrate film 102, 200nm of up substrate film 103 which consists of aluminum 203 by the RF magnetron sputtering method was formed. The mixed gas of NH3, O2, N2, and Ar was used for reactant gas at the target using aluminum. Membrane formation temperature was made into 300 degrees C. The other production approaches produced the piezo electric crystal thin film like the 1st example. The cross section of a piezo electric crystal thin film was observed with the scanning electron microscope. Although not illustrated, it turned out that there is also no exfoliation and the precise piezo electric crystal thin film is formed.
[0028] Next, the 3rd example of the piezo electric crystal thin film in the gestalt of operation of the 1st of this invention is explained. On Si single crystal substrate 101, the lower substrate film 102 which consists of SiO2 film was formed 200nm of thickness. 500nm of up substrate film 103 which consists of MgO by the RF magnetron sputtering method was formed on the lower substrate film 102. The mixed gas of O2 and Ar was used for reactant gas at the target using Mg. Membrane formation temperature was made into 300 degrees C. The other production approaches produced the piezo electric crystal thin film like the 1st example. The cross section of a piezo electric crystal thin film was observed with the scanning electron microscope. It is forming [the adhesion between the substrate film 103 and the lower electrode 104 is good, and]-precise piezo electric crystal thin film ****** although not illustrated.
[0029] Next, the piezo electric crystal thin film of the 4th example in the gestalt of operation of the 1st of this invention is explained. The sulfuric-acid system etching reagent performed method etching of ** from the rear face to the substrate using the GaAs single crystal substrate. Other production approaches were performed like the gestalt of the 1st operation, and produced the piezo electric crystal thin film. Although not illustrated, the adhesion between the substrate film 103 and the lower electrode 104 of the obtained piezo electric crystal thin film was good, and it turned out that the precise piezo electric crystal thin film is formed. Moreover, the substrate film 103 had tensile stress and

it turned out that there is effectiveness of stress adjustment.

[0030] Next, the piezo electric crystal thin film in the 2nd example of a comparison is explained. 100nm of substrate film 102 which consists of SiO_2 was formed using the GaAs single crystal substrate. Others produced the piezo electric crystal thin film like the 4th example of the gestalt of the 1st operation. Although exfoliation was not produced between the substrate film 102 and the lower electrode 104, it turned out that a piezo electric crystal thin film is not precise like the example of the 1st comparison. Furthermore, since all the internal stress of the substrate film 102, the lower electrode 104, and the piezo electric crystal thin film 105 was these directions, since great stress joined the substrate, the substrate deformed, and the problem of being inferior to component dependability arose.

[0031] The 5th example of the piezo electric crystal thin film in the gestalt of operation of the 1st of this invention is explained. Like the 1st example, after forming the substrate film 102 and 103, the lower electrode 104 which consists of Ir/Ti was formed. The formation approach of a lower electrode was performed by the RF magnetron sputtering method, and used Ar gas at the substrate temperature of 300 degrees C. Each thickness was set to Ir:200nm and Ti:50nm. Furthermore, the Au/Ti film was used for the up electrode. Thickness could be Au:70nm and Ti:30nm. The membrane formation approach used vacuum deposition. All of a piezo electric crystal film formation process, a substrate etching process, etc. were performed like the 1st example of the gestalt of the 1st operation, and they produced the piezo electric crystal thin film. Although not illustrated, exfoliation was not produced between the substrate film 103 and the lower electrode 104. Moreover, it turned out that the precise piezo electric crystal thin film has been obtained.

[0032] The 6th example of the piezo electric crystal thin film in the gestalt of operation of the 1st of this invention is explained. After forming the substrate film 102 and 103 like the 1st example, the lower electrode 104 which consists of Pt/Ti was formed. The formation approach of a lower electrode was performed by the RF magnetron sputtering method, and used the substrate temperature of 600 degrees C, and Ar gas. Each thickness was set to Pt:150nm and Ti:30nm. Furthermore, the Au/Ti film was used for the up electrode. Thickness could be Au:70nm and Ti:30nm. The membrane formation approach used vacuum deposition. All of a piezo electric crystal film formation process, a substrate etching process, etc. were performed like the 1st example, and they produced the piezo electric crystal thin film. Although not illustrated, exfoliation was not produced between the substrate film 103 and the lower electrode 104.

gestalt of operation of the 1st of this invention is explained. The piezo electric crystal thin film was produced like the 9th example. Here, the AlN thin film was used for the piezo electric crystal thin film 105. The AlN thin film was formed by RF magnetron sputtering. N2 was made into sputtering gas at the target using aluminum, and substrate temperature of 600 degrees C and thickness were set to 1 micrometer. Although not illustrated, the precise piezo electric crystal thin film 105 was obtained good by the adhesion between the substrate film 103 and the lower electrode 104.

[0037] Next, the filter in the gestalt of operation of the 2nd of this invention is explained. Drawing 6 shows the structure of the produced filter. In creation of this filter, the substrate film 102 and 103, the two-layer lower electrode 104, and the two-layer piezo electric crystal thin film 105 were formed like the 1st example of the gestalt of the 1st operation on Si single crystal substrate 101. It was made to arrange in parallel two pieces, having used the configuration of the up electrode 106 as 20 micrometers * 100 micrometers. The membrane formation conditions of the up electrode 106 were made to be the same as that of the 1st example. Using the air bridge 108 formed by Au/Ti plating from each up electrode 106, it was made to connect with the pad 109 for electrode ejection, and considered as the electrode for I/O. The rear face of Si single crystal substrate 101 was dissolved in anisotropic etching like the 1st example. In this way, the filter adapting a piezo electric crystal thin film was produced. Consequently, etching could be suspended by the substrate film 102 and the adhesion of the substrate film 103 and the lower electrode 104 was able to obtain the precise piezo electric crystal thin film 105 good.

[0038] When the Q value of the piezoelectric film of the resonator shown in the 1st example of the gestalt of the 1st operation of the above and the resonator measured from the resonator produced in the example of the 1st comparison was analyzed from measured value, the latter was 65 to the former having been 220. It is an index showing the magnitude of the loss produced in the case of propagation of an elastic wave, the Q value shown here is expressed with the formula of Q= 1-/loss, and it means that it is low loss, so that a numeric value is large. Thus, chemically, it had the up substrate film 103 of the quality of the material precise in addition to stable lower substrate film 102 with little acoustical loss, and the effectiveness that acoustical loss of a piezo electric crystal thin film could be reduced also found a certain thing by forming the substrate film which consists of two or more layers.

[0039] Next, the filter in the gestalt of operation of the 3rd of this

invention is explained. Drawing 7 shows the structure of the produced filter. First, the lower substrate film 102 which consists of SiNx film was formed on Si single crystal substrate 101 at 100nm of thickness. The middle substrate film 103 which consists of AlN was formed on the lower substrate film 102 at 2 micrometers of thickness. Here, the lower substrate film 102 was formed by the same approach as the 1st example of the gestalt of the 1st operation. The formation approach of the middle substrate film 103 used aluminum target by the RF magnetron sputtering method. The mixed gas of Ar and O2 was used for substrate temperature as 650 degrees C and sputtering gas. Furthermore, the up substrate film 111 which consists of SiO2 was formed on the middle substrate film 103 at 2.5 micrometers of thickness. The up substrate film 111 was formed by the same approach as the 1st example of the gestalt of the 1st operation. The laminating of each film was carried out like the gestalt of the 2nd operation on the substrate film 111, and the filter was produced. Consequently, the filter which has a precise piezo electric crystal thin film, and has a property with little acoustical loss like the gestalt of the 2nd operation was obtained.

[0040] The surface acoustic element in the gestalt of operation of the 4th of this invention is explained. Drawing 8 shows the structure of a surface acoustic element. First, the lower substrate film 102 which consists of SiNx, and the up substrate film 103 which consists of SiO2 were formed by the same approach as the 1st example of the gestalt of the 1st operation on Si single crystal substrate 101. Next, on the up substrate film 103, PtTiO3 was formed and the piezo electric crystal thin film 105 was formed. Next, the crossover finger electrodes 114 and 115 which consist of Pt/Ti were formed on the piezo electric crystal thin film 105. In this way, the piezo electric crystal thin film was produced.

[0041] In addition, although the gestalt of the 1st operation explained the resonator, the gestalt of the 2nd and the 3rd operation explained the filter and the gestalt of the 4th operation explained the surface acoustic element, this invention is applicable to other various components with the configuration of an electrode.

[0042]

[Effect of the Invention] Two or more substrate film in which the 1st piezo electric crystal thin film concerning this invention carried out sequential formation on the substrate and the substrate, The conductor thin film which is the 1st electrode which was formed on the substrate film, and which drives a piezo electric crystal, The 2nd piezo electric crystal thin film which consists of a piezo electric crystal thin film

Moreover, it turned out that the precise piezo electric crystal thin film has been obtained.

[0033] The 7th example of the piezo electric crystal thin film in the gestalt of operation of the 1st of this invention is explained. After forming the substrate film 102 and 103 like the 1st example, the lower electrode 104 which consists of RuO2 was formed. The formation approach of a lower electrode was performed by the RF magnetron sputtering method, and set thickness to 100nm using the substrate temperature of 300 degrees C, and the mixed gas of Ar and O2. Furthermore, aluminum film was used for the up electrode. Thickness could be 10nm. The membrane formation approach used vacuum deposition. All of a piezo electric crystal film formation process, a substrate etching process, etc. were performed like the 1st example, and they produced the piezo electric crystal thin film. Although not illustrated, exfoliation was not produced between the substrate film 103 and the lower electrode 104. Moreover, it turned out that the precise piezo electric crystal thin film has been obtained.

[0034] The 8th example of the piezo electric crystal thin film in the gestalt of operation of the 1st of this invention is explained. After forming the substrate film 102 and 103 and the lower electrode 104 on Si single crystal substrate 101 like the 1st example, the piezo electric crystal thin film 105 which consists of PZT was formed by the RF magnetron sputtering method. The piezo electric crystal thin film 105 formed membranes to the mixed gas of Ar and O2, the substrate temperature of 650 degrees C, and 800nm of thickness, using the sintered compact of PZT as a target. Etching of the up electrode 106 and Si substrate was performed like the 1st example, and the piezo electric crystal thin film was produced. Although not illustrated, the precise piezo electric crystal thin film 105 was obtained good by the adhesion between the substrate film 103 and the lower electrode 104.

[0035] The 9th example of the piezo electric crystal thin film in the gestalt of operation of the 1st of this invention is explained. The piezo electric crystal thin film was produced like the 8th example. Here, the ZnO thin film was used for the piezo electric crystal thin film 105. The ZnO thin film was formed by the RF magnetron sputtering method. O2 was used for sputtering gas at the target using Zn. Substrate temperature was made into 500 degrees C, and thickness could make it 5 micrometers. Consequently, the precise piezo electric crystal thin film 105 was obtained good by the adhesion between the substrate film 103 and the lower electrode 104.

[0036] The 10th example of the piezo electric crystal thin film in the

formed on the conductor thin film, and 2nd at least one electrode formed on the piezo electric crystal thin film, and starts this invention It consists of at least one electrode formed on the substrate and the substrate at one side of two or more substrate film which carried out sequential formation, the piezo electric crystal thin film formed on the substrate film, and a piezo electric crystal thin film. That is, the substrate film consists of two or more layers. Thereby, the adhesion between the substrate film and the film of the upper layer and the quality of a piezo electric crystal thin film have been improved. Moreover, since the substrate film which touches having carried out eburnation of the piezo electric crystal thin film and a piezo electric crystal thin film is precise, the new effectiveness that acoustical loss of a piezo electric crystal thin film is reduced is acquired. Moreover, the residual stress of the whole piezo electric crystal thin film can be adjusted by adjusting the residual stress of each substrate film. Consequently, the engine performance, the dependability, and the yield of a piezo electric crystal thin film have been improved by leaps and bounds.

[0043] Since one of the substrate film uses any one or more of silicon nitride, silicon oxide, tantalum oxide, an aluminum oxide, and the magnesium oxides as a principal component, the resistance over the alkali solution of the substrate film is high. Moreover, since a piezo electric crystal thin film uses any one or more of lead titanate, titanic-acid lead zirconate, a zinc oxide, and the alumimium nitride as a principal component, thin film creation is easy. Moreover, since a conductor thin film uses at least one in platinum, iridium, a ruthenium, and ruthenium oxide as a principal component at a titanium list, the conductor thin film is chemically stable, and excellent in adhesion. Moreover, since a substrate consists of single crystal silicon or single crystal gallium arsenide, the substrate film of various properties can be chosen. Moreover, since it has the configuration where the above-mentioned substrate removed the part of a piezo electric crystal thin film which touches the oscillating section at least, exsorption of the vibrational energy to the substrate section is prevented with this configuration. Moreover, the component which was chemically excellent in the engine performance as stable film in the substrate film which touches a substrate since the substrate film which the substrate film which a substrate consists of single crystal silicon and touches the substrate in two or more substrates film uses silicon nitride as a principal component, and touches a conductor thin film uses silicon oxide as a principal component, a conductor thin film uses titanium and

platinum as a principal component and a piezo electric crystal thin film uses lead titanate as a principal component is obtained.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the diagrammatic sectional view of the oscillator in the 1st operation gestalt of this invention.
[Drawing 2] It is drawing of the cross-section SEM image of the piezo electric crystal thin film in this piezo electric crystal thin film.
[Drawing 3] It is the diagrammatic sectional view showing the structure of the piezo electric crystal thin film in the example of the 1st comparison.
[Drawing 4] It is drawing of the cross-section SEM image of the piezo electric crystal thin film in this piezo electric crystal thin film.
[Drawing 5] It is drawing of the cross-section SEM image of the piezo electric crystal thin film of the example of the 2nd comparison.
[Drawing 6] It is the diagrammatic top view of the filter of the 2nd operation gestalt of this invention.
[Drawing 7] It is the diagrammatic sectional view of the filter of the 3rd operation gestalt of this invention.
[Drawing 8] It is the diagrammatic sectional view of the surface acoustic element of the 4th operation gestalt of this invention.
[Description of Notations]
101 Substrate 102 Substrate film 103 The substrate film, 104 Lower electrode 105 Piezo electric crystal thin film 106 106' An up electrode, 107 Bahia hall 108 Air bridge 109 Pad 110 Exfoliation 111 Substrate film 114 115 Electrode.

[Translation done.]

* NOTICES *

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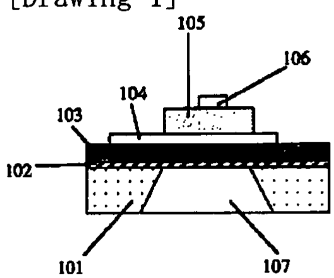
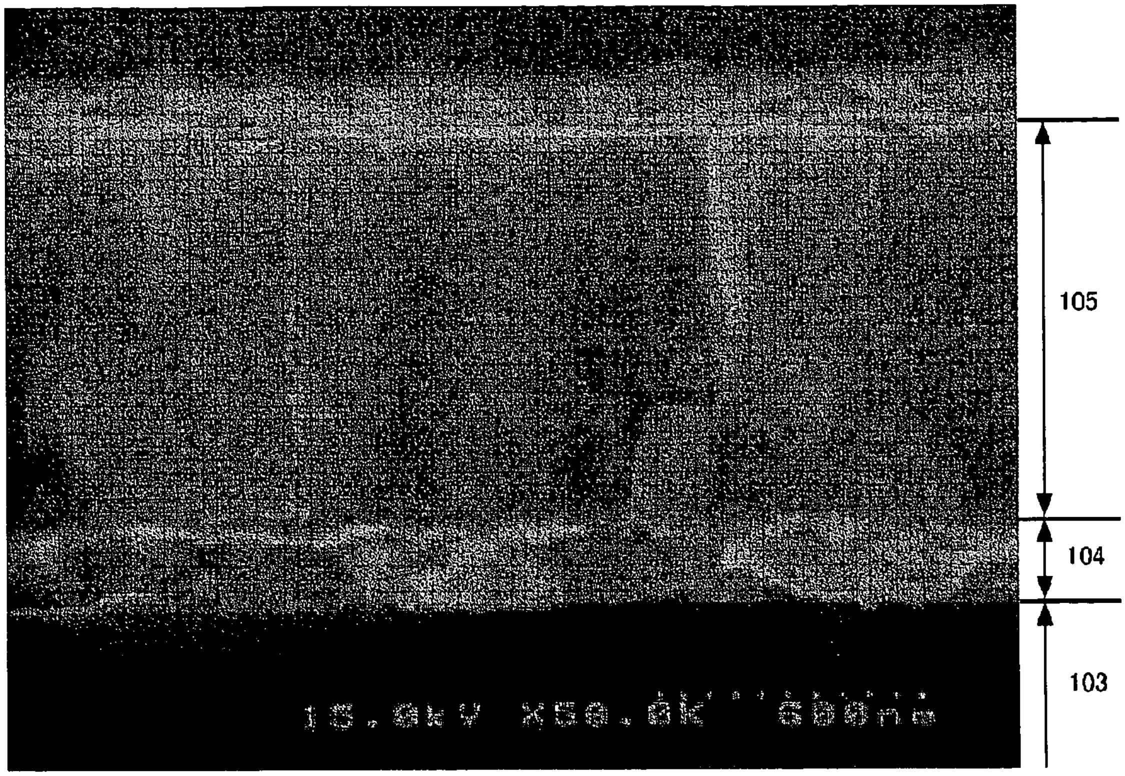
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DRAWINGS

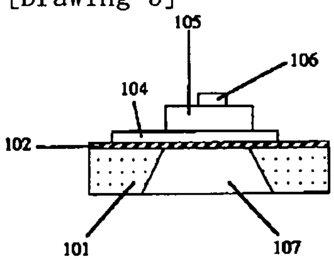
[Drawing 1]



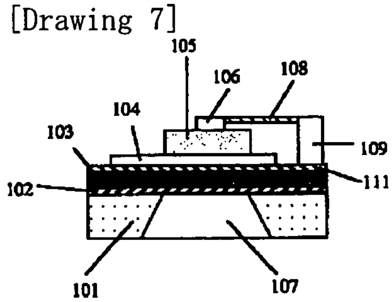
[Drawing 2]



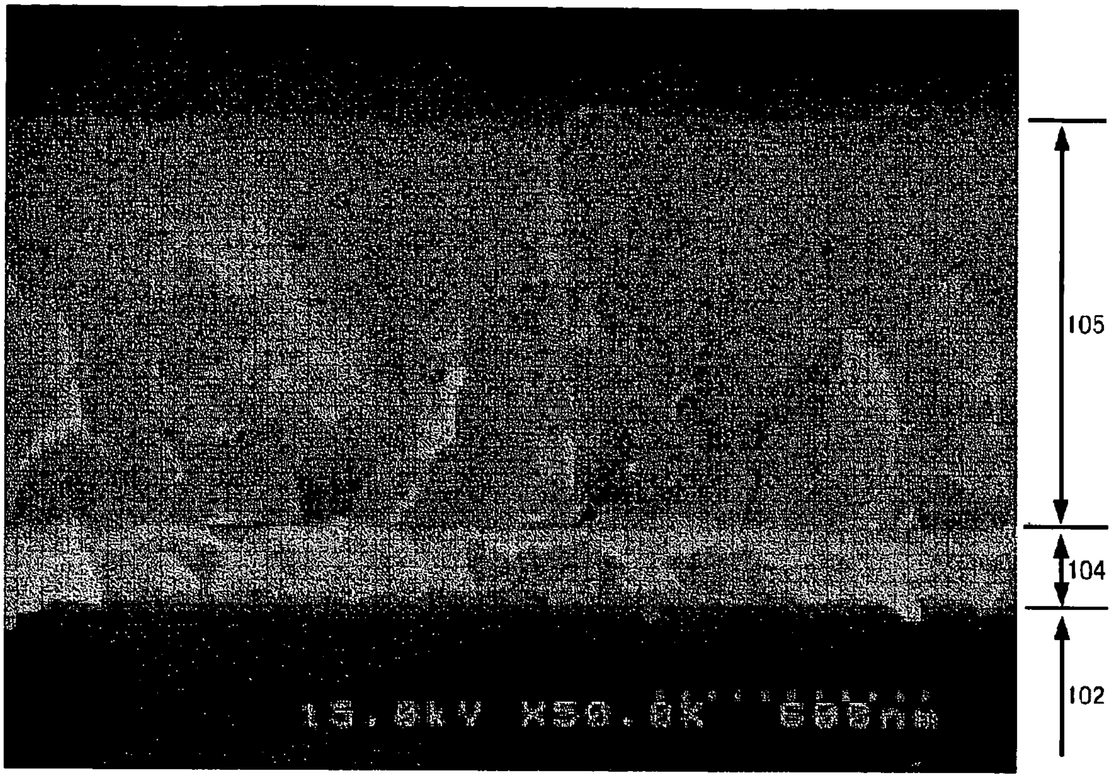
[Drawing 3]



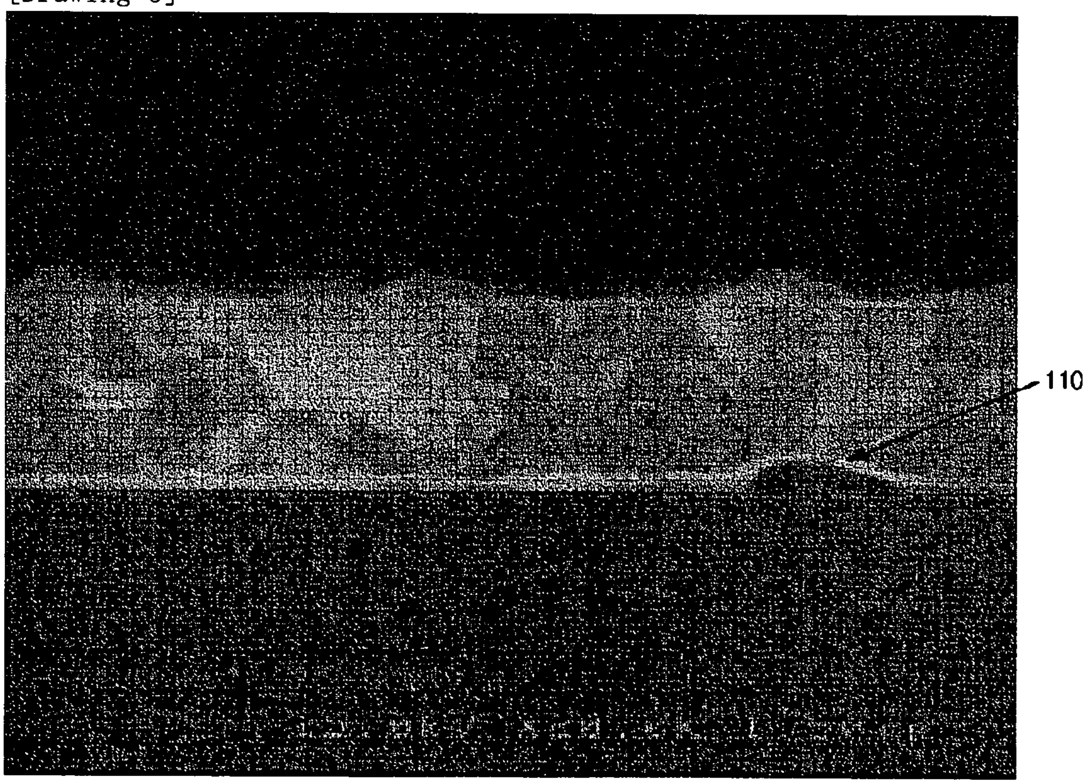
[Drawing 7]



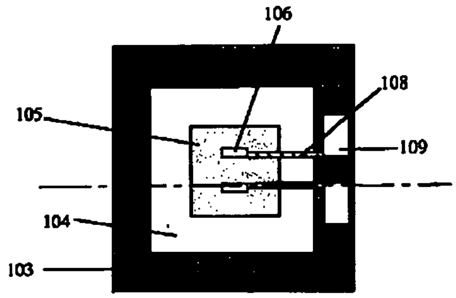
[Drawing 4]



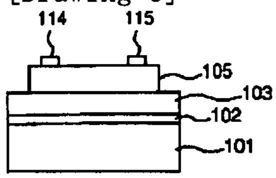
[Drawing 5]



[Drawing 6]



[Drawing 8]



[Translation done.]